A LITTER BOX METHOD FOR THE STUDY OF LITTER ARTHROPODS

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ABSTRACT

A litter box designed to be used in litter decomposition and habitat structure experiments is described. The litter box allows litter to vary in shape during decomposition or permits modification of leaf shape prior to placement in the field. Litter boxes, placed in hardwood forest litter for one month, contained significantly greater densities of arthropods than did natural litter, suggesting a potential litter box effect. The influence of leaf shape on populations of litter-inhabiting spiders is discussed.

Key Words: Litter spatial heterogeneity, litter bag/box effect, leaf shape, Theridiidae

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INTRODUCTION

The development of the litter bag method (Crossley and Hoglund 1962) was an important contribution to studies of litter decomposition and associated succession of litter fauna. Numerous studies have employed this technique to measure rates of litter decomposition (e.g.,Heath *et al.* 1966, Anderson 1973a, 1973b, 1975, Norton and Dindal 1976). However, two problems have arisen from use of litter bags. First, litter bag fauna are often quite different from fauna in natural litter in terms of both species composition and numerical abundance. This difference is known as the litter bag effect. The litter bag effect has been attributed to a more stable micro-climate within a bag due to the boundary air-layer control principle (Robinson 1979) and to exclusion of predators which are larger than bag mesh size.

Secondly, litter bags are generally constructed to lie flat on the soil surface with a minimum of three-dimensional structure. However, the spatial heterogeneity of leaf litter in the three-dimensional aspect is important in decomposition (Edwards *et al.* 1970, Anderson 1975) and for litter fauna species composition (Uetz 1975, 1979, Anderson 1978, Stanton 1979). For example, leaves have been classified according to their physical characteristics (Heatwole 1961). Curled or bent leaves have greater interstitial space than do flat leaves. Litter habitat space increases when the proportion of curled or bent leaves increases or when the proportion of flat leaves decreases (Uetz 1974, Bell and Sipp 1975).

We have designed a litter box method which allows litter to vary in shape during decomposition or permits modification of leaf shape prior to place-

ment in the field. As with litter bags, arthropods invade the boxes readily and can be extracted in Tullgren funnels. Finally, sampling at regular intervals will permit analysis of litter decomposition rates.

METHODS

The details for construction of a litter box are presented in Figure 1. Boxes are constructed of metal hardware cloth (6.35 mm openings); a five-sided enclosure is attached to a sheet of hardware cloth to complete each box. The size and shape of a litter box can vary, but we have used small boxes (10 cm x 10 cm x 2 cm) to facilitate replication and to increase funnel extraction efficiency. Further, hardware cloth with larger openings may be used to permit entry of all macroinvertebrates, although more fragmented litter may be lost through these openings during decomposition.

A large quantity of freshly-fallen *Acer saccharum* L. leaves were collected, wetted in distilled water, and either pressed flat in a plant press or rolled into a tube. Into each of six litter boxes, 10 flat leaves were placed, while 10 rolled leaves were put in each of six other boxes. All twelve litter boxes were placed in a mixed hardwood site at the Lafayette Experimental Station, Syracuse, New York, on October 1, 1979.

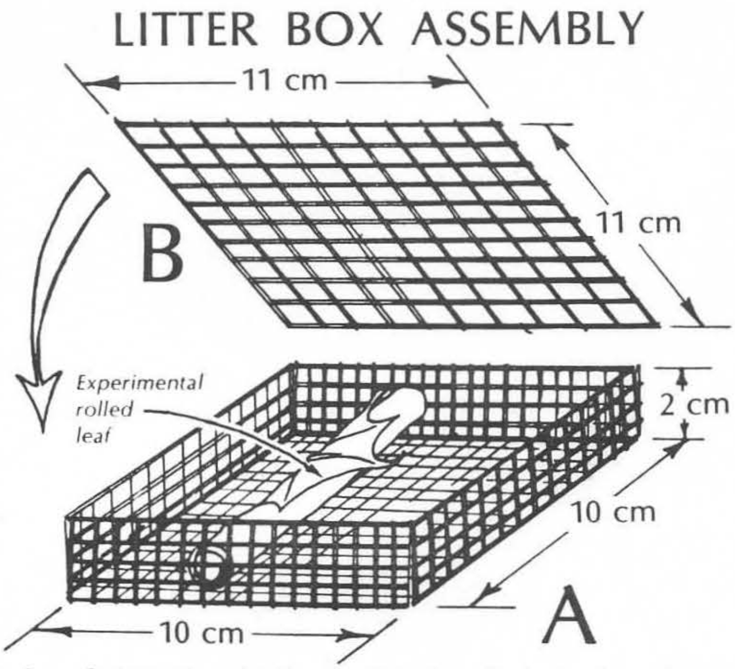

Fig. 1. – Construction details of a litter box. Both the five-sided enclosure (A) and the flat sheet (B) are made of 0.25 inch (6.36 mm) metal hardware cloth. The flat sheet may be attached to the enclosure with fishing line or wire and the completed assembly (including litter) is positioned on soil using wooden stakes or nails. Note that larger box dimensions and/or larger mesh openings are possible.

Six boxes, three of each litter form, were removed on November 1, 1979, while the remaining boxes were collected on December 1, 1979. One sample of natural litter (1 dm^2) was removed from a site adjacent to each litter box on the appropriate date. Arthropods in boxes and in natural litter samples were extracted in steep-sided Tullgren funnels. Densities of major arthropod taxa were analyzed for the November samples whereas only the abundance of immature spiders (*Enoplognatha ovata* [Clerck] : Theridiidae) were evaluated for the December samples.

RESULTS AND DISCUSSION

Results of litter arthropods extracted from litter boxes and natural litter samples collected in November are presented in Table 1. Total mean densities of arthropods extracted from boxes containing flat leaves did not differ significantly from densities in boxes containing rolled leaves ($t = 0.937$; $df = 4$, $p > 0.05$). Thus, results for arthropod abundance in litter boxes were pooled and compared to results for natural litter samples.

Pooled arthropod densities were significantly greater than those in natural litter for the November samples ($t = 6.596$, $df = 10$, $p < 0.001$), suggesting that a litter box effect was present. Further, significantly greater numbers of Collembola ($t = 3.471$, $df = 10$, $p < 0.01$) and Araneae ($t = 3.357$, $df = 10$, $p < 0.01$) were found in litter boxes (Table 1).

The possible litter box effect demonstrated by these results may be attributed to several differences between conditions in the boxes and those in natural litter. First, since litter in the boxes was wetted for flattening or rolling, microbial populations may have been activated, causing subsequent increases in certain arthropod taxa (e.g., Collembola). A number of re-

Table 1. Densities of major arthropod taxa in litter boxes and natural litter samples ($\bar{X} \pm S.E.$).

TAXA	LITTER BOXES		NATURAL LITTER
	Round Leaves (n = 3)	Flat Leaves (n = 3)	(n = 6)
ARACHNIDA			
Araneae	2.67 ± 1.45	5.00 ± 1.53	0.17 ± 0.17
Acarina	1.33 ± 1.33	2.00 ± 1.53	2.67 ± 1.89
INSECTA			
Collembola	53.33 ± 12.25	35.33 ± 13.86	8.67 ± 4.57
Psocoptera	0.00 ± 0.00	0.33 ± 0.88	1.33 ± 0.42
Coleoptera	0.00 ± 0.00	1.33 ± 0.88	0.50 ± 0.22
TOTALS	57.33 ± 14.11	44.00 ± 10.21	
	50.67 ± 8.34		13.33 ± 5.90**

**$p < 0.001$.

searchers have shown that microbial activity within air-dried soils is greater after rewetting than it was prior to drying (Lebedjantev 1924, Stevenson 1957, Birch 1958, Stotzky *et al.* 1962). Secondly, significantly greater arthropod densities in litter boxes may have resulted from exclusion of large-bodied predators.

Since modifications of litter conditions (both structure and micro-climate) are required for all litter decomposition studies employing bags or boxes, it is likely that results on arthropod communities obtained from these techniques will consistently differ from arthropod community data from natural litter. However, this does not diminish the utility of our method for analysis of litter habitat structure.

For example, densities of immature theridiid spiders were greatest in rolled litter in both November and December (Table 2). Densities of these spiders in litter boxes containing flat leaves were significantly greater than comparable populations in natural litter (November: $t = 3.177$, $df = 7$, $p < 0.02$; December: $t = 4.527$, $df = 7$, $p < 0.01$). However, differences between *E. ovata* populations in litter boxes with rolled leaves and those in natural litter were more pronounced (November: $t = 3.761$, $df = 7$, $p < 0.01$; December: $t = 14.985$, $df = 7$, $p < 0.001$).

Litter shape strongly influences the structure of leaf litter spider communities. For example, Uetz (1975, 1979) has demonstrated that differences in the spatial distribution of forest litter wandering spiders are associated with the amount of litter habitat space. Dominance by Lycosidae is greatest in compressed litter made up of flat leaves and decreases with increasingly deep litter, containing more bent and curled leaves. The importance of Clubionidae, Gnaphosidae, and Thomisidae increases as litter becomes deeper and more complex (Uetz 1979). Species in the latter two families used naturally rolled leaves for retreats (Kaston 1948). There are relatively few quantitative analyses of the use of curled leaves by web-building spiders (but see Waldorf 1976), although several families (including Theridiidae) are known to build retreats in curled leaves within litter (Kaston 1948, Lubin 1978). Our data suggest that the scarcity of rolled leaves may be a limiting resource for populations of immature *E. ovata.*

The litter box will permit analysis of arthropod communities inhabiting litter of specific shape, particularly the large but poorly-understood community of web-building litter-inhabiting spiders. More importantly, this tech-

Table 2. – Densities of immature *Enoplognatha ovata* (Clerck) (Araneae: Theridiidae) in litter boxes and natural litter samples over two months ($\bar{x} \pm$ S.E.).

MONTH	LITTER BOXES		NATURAL LITTER
	Flat Leaves (n = 3)	Round Leaves (n = 3)	(n = 6)
November	2.33 ± 1.20	4.33 ± 2.03	0.17 ± 0.17**
December	4.00 ± 1.53	10.00 ± 1.15	0.17 ± 0.17**

**$p < 0.02$.

nique provides discrete, replicable samples which can be collected at any season.

CONCLUSIONS

1. This litter box is an effective method for measuring the effect of litter structure on arthropod communities.

2. A litter box effect is suggested by our data; however, similar effects are likely in all experimental manipulations of litter enclosed in bags or boxes.

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LITERATURE CITED

Anderson, J. M. 1973a. The breakdown and decomposition of sweet chestnut (*Castanea sativa* Mill.) and beech (*Fagus sylvatica* L.) leaf litter in two deciduous woodland soils. I. Breakdown, leaching and decomposition. Oecologia 12: 251-74.

Anderson, J. M. 1973b. The breakdown and decomposition of sweet chestnut (*Castanea sativa* Mill.) and beech (*Fagus sylvatica* L.) leaf litter in two deciduous woodland soils. II. Changes in carbon, hydrogen, nitrogen and polyphenol content. Oecologia 12: 275-8.

Anderson, J. M. 1975. Succession, diversity and trophic relationships of some soil animals in decomposing leaf litter. J. Anim. Ecol. 44: 475-95.

Anderson, J. M. 1978. Inter- and intra-habitat relationships between woodland Cryptostigmata species diversity and the diversity of soil and litter microhabitats. Oecologia 32: 341-8.

Bell, D. T and S. K. Sipp. 1975. The litter stratum in the streamside ecosystem. Oikos 26: 391-7.

Birch, H. F. 1958. The effect of soil drying on humus decomposition and nutrient availability. Plant and Soil 10: 9-31.

Crossley, D. A., Jr. and M. P. Hoglund. 1962. A litter-bag method for the study of microarthropods inhabiting leaf litter. Ecology 43: 571-3.

Edwards, C. A., D. A. Reichle, and D. A. Crossley, Jr. 1970. The role of soil invertebrates in turnover of organic matter and nutrients, pp. 147-72. *In* D. E. Reichle (ed.), Analysis of Temperate Forest Ecosystems, Ecological Studies 1. Springer-Verlag, New York.

Heath, G. W., M. K. Arnold, and C. A. Edwards. 1966. Studies in leaf litter breakdown. I. Breakdown rates of leaves of different species. Pedobiologia 6: 1-12.

Heatwole, H. 1961. Analysis of the forest floor habitat with a structural classification of the litter or L layer. Ecol. Monogr. 31: 261-83.

Kaston, B. J. 1948. The spiders of Connecticut. State Geol. Nat. Hist. Surv. Conn. Bull. No. 70. 855 pp.

Lebedjantev, A. N. 1924. Drying of soil as one of the natural factors in maintaining soil fertility. Soil Sci. 18: 419-47.

Lubin, Y. D. 1978. Seasonal abundance and diversity of web-building spiders in relation to habitat structure on Barro Colorado Island, Panama. J. Arachnology 6: 31-51.

Norton, R. A. and D. L. Dindal. 1976. Structure of the microarthropod community in Lake Ontario beach debris. Environ. Entomol. 5: 773-9.

Robinson, D. 1979. Cold facts about Thinsulate. Mariah/Outside Magazine 4 (5): 89-91.

Stanton, N. L. 1979. Patterns of species diversity in temperate and tropical litter mites. Ecology 60: 295-304.

Stevenson, I. L. 1957. Some observations on the microbial activity in remoistened air-dried soils. Plant and Soil 8: 170-82.

Stotzky, G., R. D. Goos, and M. I. Timonin. 1962. Microbial changes occurring in soil as a result of storage. Plant and Soil 16: 1-18.

Uetz, G. W. 1974. A method for measuring habitat space in studies of hardwood forest litter arthropods. Environ. Entomol. 3: 313-15.

Uetz, G. W. 1975. Temporal and spatial variation in species diversity in wandering spiders (Araneae) in deciduous forest litter. Environ. Entomol. 4: 719-24.

Uetz, G. W. 1979. The influence of variation in litter habitats on spider communities. Oecologia 40: 29-42.

Waldorf, E. S. 1976. Spider size, microhabitat selection and use of food. Amer. Midl. Nat. 96: 76-87.

J. Georgia Entomol. Soc. 16(2), April, 1981, 151-156